Officer Overexecution: Analysis and Solutions (Technical Background)

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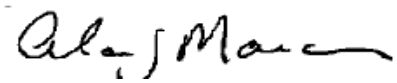

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Abstract

Understanding surface warfare officer (SWO) retention is critical for accession planning and community management. In this information memorandum, we estimate the relationship between SWO retention and the strength of the civilian economy. We estimate that a one-unit increase in an index of macroeconomic activity (indicating a worsening of the economy) increases conventional SWO retention by 2.6 percentage points. By design, the index is forecastable and could be used to project conventional SWO retention rates. Retention rates of SWOs with the nuclear subspecialty (SWO(N)s) show no consistent relationship with economic conditions.

We also estimate the relationship between SWO retention and exposure to early-career officer overexecution (OOE). We find no consistent relationship between the amount of OOE on the platform of first assignment and the retention rates of conventional SWOs or male SWO(N)s. We find that female SWO(N) retention rates are affected by OOE, particularly OOE in paygrade O2.

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Executive Summary

In a CNA study sponsored by the Director, Warfare Integration Division (N9I), we examine various aspects of officer overexecution (OOE).[1] OOE occurs when the size of an officer inventory exceeds the number of billets authorized (BA) for the paygrade. OOE occurs primarily in the junior officer (JO) portion of the Surface Warfare Officer (SWO) community, where current-year accessions are planned to meet future department head (DH) and other mid-grade officer requirements.

If current-year SWO accessions were planned to meet SWO JO BA, it is likely that future SWO DH and other mid-grade requirements would not be filled. This is because, historically, SWO JO retention has not been high enough to create an inventory profile that equals both SWO JO BA and SWO DH and other mid-grade officer requirements. Instead, the Navy has "overexecuted" SWO JOs to ensure that future SWO DH and other mid-grade officer requirements can be met. Thus, understanding the factors that affect SWO retention is critical for SWO accession planning and community management.

This information memorandum provides details of analysis that we conducted for task 4 in *Officer Overexecution: Analysis and Solutions.* In task 4, we were asked if we could better anticipate changes in SWO retention. In this study, we build on recent CNA analyses to improve our ability to anticipate changes in SWO retention. CNA recently developed a model of SWO retention for the Assistant Secretary of the Navy (Manpower and Reserve Affairs) (ASN (M&RA)) in which the authors included the effect of an index summarizing various measures of the civilian economy.[2] The economic index that the authors used in the analysis for ASN (M&RA) was a summary of 12 separate macroeconomic measures, including the unemployment rate, labor force participation rates, and personal consumption expenditures. Using historical data, the authors found that SWO retention is highly correlated with the economic index.

[1] Ann D. Parcell, 2015, *Officer Overexecution: Analysis and Solutions,* CNA DAB-2015-U-011041-Final.

[2] Yevgeniya K. Pinelis and Jared M. Huff, 2015, *The Economy and Navy Officer Retention,* CNA DRM-2015-U-009595-Final.

Although the index helped explain historical SWO retention behavior, we do not have credible forecasts of all of the components of that index. Therefore, we cannot incorporate the effect of a *forecast* of the index into estimates of *future* SWO retention. In another recent CNA study, the same authors examined the effect of the civilian economy on enlisted retention.[3] The authors also used an index to summarize the civilian economy but limited the measures included in that index to those for which we have forecasts.

In this study, we combine the approaches in the aforementioned studies by Pinelis and Huff. We create an index that summarizes various measures of the civilian economy but include only measures for which we have a forecast. We then include the redefined economic index in a model of SWO retention. We find that the redefined index fits the historical patterns of SWO retention better than the unemployment rate alone does. We also find that the retention behavior of conventional SWOs is sensitive to this redefined economic index. We estimate that for every one-unit (i.e., one-standard-deviation) increase in the redefined economic index (indicating a worsening of the economy), conventional SWO retention increases by 2.6 percentage points, holding constant other factors that affect retention. By contrast, we found no consistent, statistically significant relationship between the retention behavior of SWOs with the nuclear subspecialty (SWO(N)s) and the redefined economic index.

In this study, we also considered how OOE may affect JO working conditions in the fleet—conditions that may, in turn, affect SWO JO retention. For example, it is possible that as the number of O1 and O2 SWOs assigned to surface platforms in excess of BA increases, the worse conditions are for initial training and obtaining warfare qualification. That is, SWOs who are first assigned to platforms with more OOE may retain at lower rates than those assigned to platforms with less OOE.

The results of our analysis do not support our hypothesis that OOE negatively affects SWO retention. We find no consistent relationship between the amount of OOE on the platform to which conventional SWOs (male or female) are first assigned and their retention behavior, holding constant other factors that affect retention. Nor do we find a relationship between the level of OOE on the platform to which male SWO(N)s are first assigned and their retention behavior. We do find, however, that the retention behavior of female SWO(N)s is affected by the amount of OOE on the platform to which they are first assigned. Specifically, we estimate that for a one-person increase in the amount of OOE, the probability of the female SWO(N) retaining to MSR+1 is about 4 percentage points *higher* than otherwise.

[3] Yevgeniya K. Pinelis and Jared M. Huff, 2014, *The Economy and Enlisted Retention in the Navy: Volume I: Main Report,* CNA DRM-2014-U-007301-Final.

It is not clear why the amount of OOE is positively correlated with female SWO(N) retention. It may be that female SWO(N) retention is responsive to a particular type of SWO crew composition, and that greater OOE simply represents a greater likelihood that a particular type of junior SWO is also a member of the crew. For example, it could be that the higher the amount of OOE, the more likely it is that there are female SWOs (conventional or nuclear) or male SWO(N)s among the O1s and O2s aboard. More analysis is needed to confirm this.

Based on our results, we recommend the following.

- Incorporate the effect of a forecast of the civilian economy in estimates of future SWO retention.
- Undertake additional analysis to understand if the estimated positive correlation of OOE and female SWO(N) retention can be leveraged to distribute these officers to their first sea assignments in ways that could increase their retention.

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Glossary

ASN (M&RA)	Assistant Secretary of the Navy (Manpower and Reserve Affairs)
BA	Billets Authorized
BCEI	Blue Chip Economic Indicators
DH	Department Head
JO	Junior Officer
MCM	Mine Countermeasure
MSR	Minimum Service Requirement
MSR–1	One Year Before the Minimum Service Requirement
MSR+1	One Year After the Minimum Service Requirement
NROTC	Naval Reserve Officer Training Corps
OMF	Officer Master File
OOE	Officer Overexecution
O1 OOE	Officer Overexecution in Paygrade O1
O2 OOE	Officer Overexecution in Paygrade O2
PCA	Principal Component Analysis
SD	Standard Deviation
SME	Subject Matter Expert
SWO	Surface Warfare Officer
SWO(N)	Surface Warfare Officer with the Nuclear Subspecialty
TFMMS	Total Force Manpower Management System
UIC	Unit Identification Code
USNA	United States Naval Academy
YCS	Years of Commissioned Service

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Introduction

This information memorandum is part of the documentation of a study of officer overexecution (OOE) in the Surface Warfare Officer (SWO) community [1]. In this N9I-sponsored study, we examine how SWO accession planning relates to OOE. A critical part of developing the SWO accession plan for the current and next few years is the assumption made about future SWO retention. Thus, in task 4 of [1], we examine SWO retention in detail.

This information memorandum provides detail on two analyses in task 4. First, we refine estimates of the relationship between SWO retention and the strength of the civilian economy made in earlier CNA work [2]. Second, we test the hypothesis that the amount of OOE on the platform to which SWOs are first assigned may affect their retention in the community.

In the first analysis, we use a SWO retention model that was recently constructed by CNA for a study for the Assistant Secretary of the Navy (Manpower and Reserve Affairs) [2]. In [2], the authors included an economic index summarizing various measures of the civilian economy in a model of SWO retention. The model also included demographic information (gender, marital status, etc.) and pre-commissioning and Navy career information (e.g., accession source, undergraduate grade-point average in science and math classes, and prior-enlisted service). Using historical data to estimate the model, the authors found that SWO retention is highly correlated with the economic index, holding constant the effect of demographic, Navy career, and other factors. The authors estimate that SWO retention changed from 15 to 30 percentage points between 2000 and 2010 as a result of its correlation with different civilian economic conditions (summarized by the index) over the time period.

The economic index that the authors used in the SWO retention analysis in [2] was a summary of 12 separate macroeconomic measures, including the unemployment rate, labor force participation rates, and personal consumption expenditures. Although the index helped explain historical SWO retention behavior, we do not have access to credible forecasts for all of the components of the economic index. Therefore, the results from [2] do not allow us to incorporate the effect of a forecast of macroeconomic activity into projections of SWO retention.

In this analysis, we construct an economic index that is composed of macroeconomic measures for which we have a professional forecast (i.e., the Blue Chip Economic

Indicators (BCEI), sometimes referred to as the blue-chip forecast). To inform our selection of measures to include in the index used in this study, we use an earlier CNA analysis in which we developed an economic index that was composed of economic measures for which there is a BCEI forecast [3]. We use this redefined—and forecastable—economic index to describe the historical relationship between the economy and SWO retention. Moreover, the results presented here can eventually be used to estimate SWO retention in the future based on a forecast of changes in economic conditions.

Our analysis of the effect of the amount of OOE on the platform to which SWOs are first assigned and their subsequent retention behavior is also informed by earlier CNA research. In [4], we tested whether crew composition affected SWO retention. Specifically, we examined whether the female percentage of the crew at the time that SWOs reported to their last division officer (DIVO) tour affected their retention from years of commissioned service (YCS) 3 to YCS 9. We found that the percentage of the crew that was female did not affect male or female conventional SWO or SWO(N)[4] retention. We suspected, however, that there were other aspects of crew composition and work conditions that may affect retention behavior. Some subject matter experts (SMEs) have suggested that an excess of junior officers (JOs) on board surface ships may not create the best conditions for early SWO training and warfare qualification. Thus, in this study, we developed a measure of SWO OOE at the time that SWOs are assigned to their first platform and estimated its effect on SWO retention.

The next section provides a brief overview of the methodology used to estimate the effect of the economy and the effect of OOE on SWO retention. A section summarizing our results follows the methodology section. We conclude this information memorandum with a short list of policy recommendations.

[4] A SWO(N) is a surface warfare officer with the nuclear subspecialty.

Methodology

We use regression analysis to estimate the relationship between the state of the civilian economy and SWO retention as well as the relationship between the amount of OOE on board SWOs' first assigned ship and their subsequent retention. To test the robustness of our results, we use both logistic and ordinary least squares regression, we vary the explanatory variables that are included in the model, and we estimate the model using data samples from different time periods.

Defining retention

In this analysis, we define retention as staying in the SWO community from one year before completion of the minimum service requirement (MSR) to one year after completion; MSR–1 and MSR+1, respectively, denote these points. As a general rule, MSR for SWOs is equal to 4 YCS for conventional SWOs. The exceptions are for those who attended the United States Naval Academy (USNA) (MSR is at YCS 5) and those who began their officer careers as SWO(N)s and transferred to the conventional SWO community early in their careers (MSR is at YCS 5). Also, MSR is always 5 YCS for SWO(N)s. The officers in our sample have MSRs that occur between 1996 and 2013.[5] For conventional SWOs, we count those who transfer to another officer community between MSR–1 and MSR+1 as losses. This decision is a result of our focus on retention from the SWO community perspective versus an all-Navy perspective.

Table 1 shows the retention rates for officers in our sample. Note that the 2-year retention rates used in this analysis may appear high to those who are accustomed to seeing retention rates defined from YCS 3 to YCS 8. We use the shorter time period because retention over a span of five years is likely influenced by a range of economic conditions. Although modeling the economic conditions over a span of this length is possible, it would be challenging to draw policy implications from such a

[5] In our data, some SWOs have other MSRs because they began and completed enough training in another community to incur a different MSR (e.g., the aviation community). These officers account for relatively few of our observations and are not included in our analysis. Also, more recently, SWOs accessing through the Naval Reserve Officer Training Corps (NROTC) scholarship program have an MSR of 5 years. For the period over which we observe the officers in our sample, however, the effect of the more recent MSR policy was not yet observable.

model. As a result, we focus on a model with more straightforward policy implications. Even over the shorter time period, as is generally reported, the retention of men is greater than that of women, and the retention of conventional SWOs is greater than that of SWO(N)s.

Table 1. Rates of retention for SWOs

	Conventional			SWO(N)		
Rate or number	Men	Women	All	Men	Women	All
Retention (MSR-1 to MSR+1)	69.7%	53.9%	66.6%	59.8%	49.2%	56.9%
Number in sample	5,976	1,498	7,474	819	315	1134

Defining the economic indices

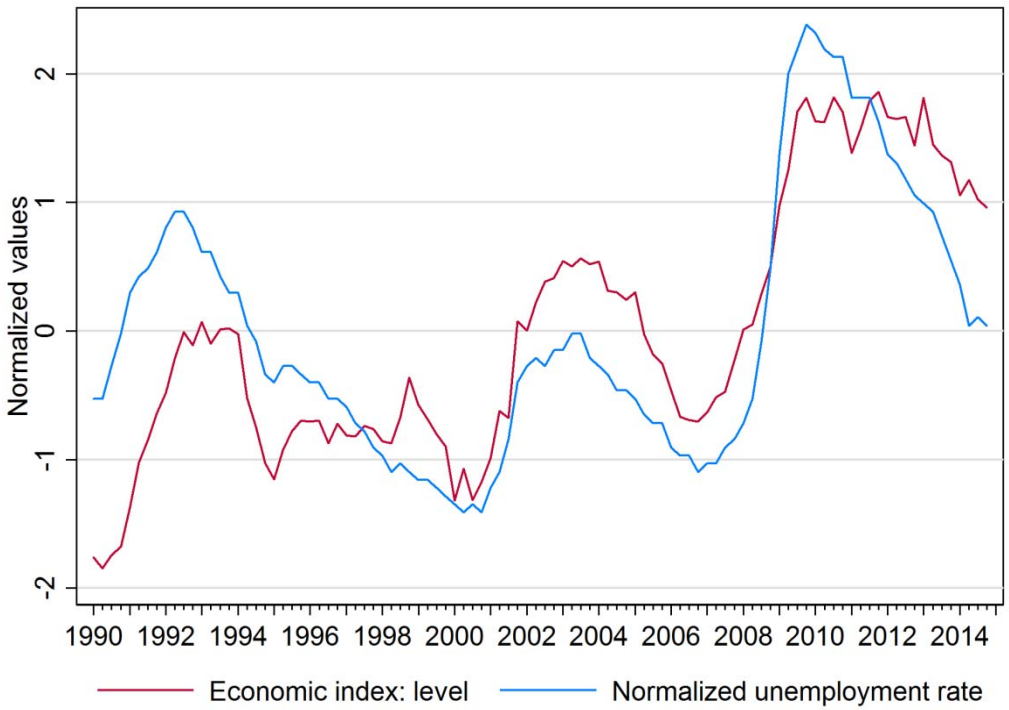
Historically, when they estimate the relationship between the economy and retention of Navy personnel, researchers have typically used some form of the civilian unemployment rate as a proxy for the state of the overall economy. Indeed, before the most recent recession, this seems to have been a reasonable measure. Since the recession, however, the unemployment rate has improved at a faster rate than has the overall economy. For example, in May 2015, the unemployment rate was below its long-term average despite the general perception that the economy was still relatively weak. In early 2014, when discussing the divergence between the unemployment rate and the health of the overall economy, Chair of the Board of Governors of the Federal Reserve Janet Yellen noted, "These observations underscore the importance of considering more than the unemployment rate when evaluating the condition of the U.S. labor market" [5].

The Navy had similar concerns about adequately measuring civilian economic conditions. In response, CNA recently explored alternate methods of describing the civilian economy (see especially [3, 6]). CNA developed a set of economic indices that contain information from a larger number of economic measures. In [6], the authors developed these indices that are forecastable, with the forecasts based on projections of the economic measures that make up the indices. For this paper, we refined our previous analysis to generate two economic indices: one that represents the current level of the economy and one that represents the growth rate of the economy. We estimate the relationship between the redefined indices and SWO retention.[6]

[6] See Appendix A for more detail on the construction of the indices used in this paper.

Broadly, the economic "level" index is composed of information from the civilian unemployment rate, 3-month Treasury bills, and 10-year Treasury notes. Since the latter two are driven primarily by Federal Reserve policy, this will, in effect, represent an unemployment rate that has been adjusted for the Federal Reserve's opinion on the state of the civilian economy. As Figure 1 shows, this results in an index that generally traces the unemployment rate but has fallen less aggressively since the most recent recession.[7]

Figure 1. The economic level index and the unemployment rate



For ease of interpretation, note that, in Figure 1,

[7] Readers may note that the index in Figure 1 varies between (roughly) 2 and -2. One of the costs of distilling the information from several variables into a single index is that the resulting index has no natural or intuitive scale; combining Treasury bill interest rates with the unemployment rate is, in some ways, like trying to convert three apples into some number of oranges. The preferred method of dealing with this problem is to convert the variable into one with a standard normal distribution, where a value of 0 represents the historical average. See Appendix A for more detail on the interpretation of the indices.

- A value of 2 represents (approximately) the worst economic conditions since 1990.
- A value of 0 represents average economic conditions since 1990.
- A value of -2 represents (approximately) the strongest economic conditions since 1990.

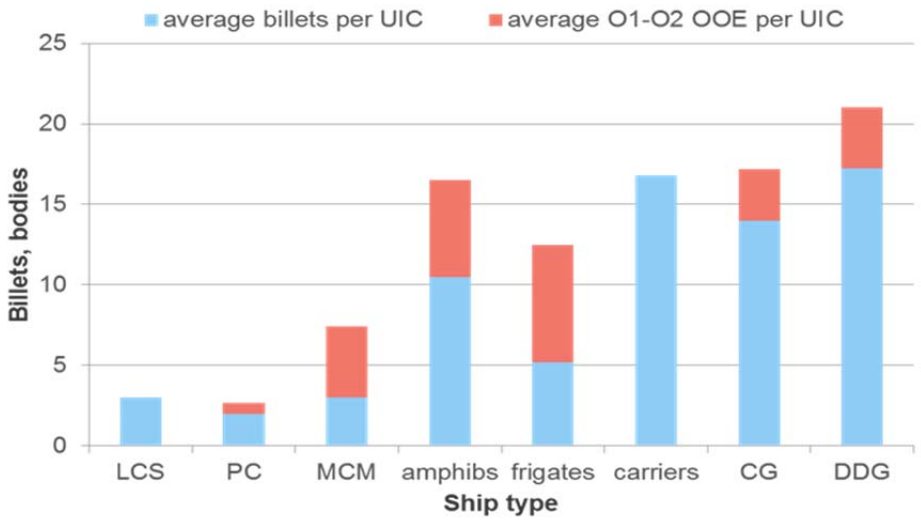
The composition of the growth index is similar to that of the economic level index: it is a combination of the growth rates of several economic variables. Since, as we show next, this index has a minimal historical relationship to retention, we relegate its discussion to Appendix A of this document. Here, it is sufficient to note that a lower economic growth index corresponds to lower growth rates (and thus a weaker economy).

Defining SWO O1-O2 OOE on ships

Another key variable of interest is the amount of paygrade O1 and O2 OOE on the ships to which SWOs are first assigned. The concern is that the greater the amount of OOE in SWOs' first assignments, the potentially lower the quality of the training environment, and the potentially greater the likelihood that SWOs will choose to leave the community. In Figure 2, we show the average amount of SWO O1-O2 OOE per ship (identified by unit identification code (UIC)) by ship class in September 2012. Figure 2 shows that—on average—amphibious ships, frigates, and mine counter-measure ships (MCMs) have proportionally more OOE than other ship types. Thus, all else equal, we might expect that SWOs who are first assigned to these ships may be less likely to stay in the SWO community.

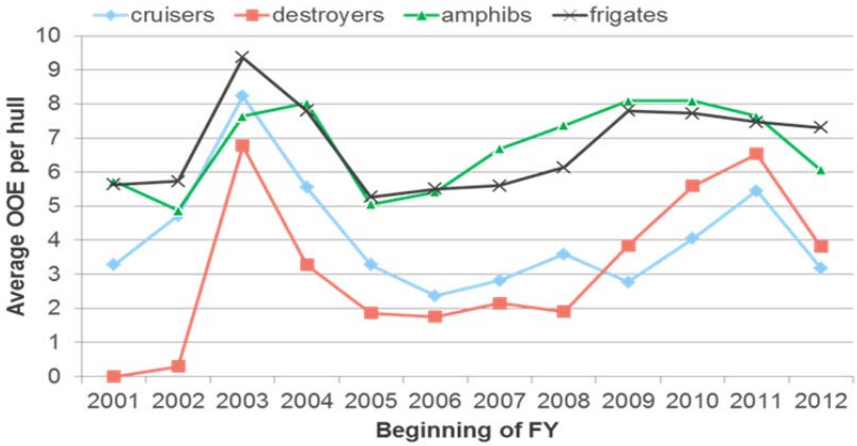
OOE can vary over time as well as by ship type. Figure 3 shows the variation in the average amount of OOE over time by ship type. Measured at the beginning of each fiscal year from 2001 to 2012, the average amount of OOE appears to have reached its lowest levels on amphibious ships, frigates, cruisers, and destroyers around FY 2005 and 2006.

Figure 2. Average O1-O2 SWO OOE versus average SWO BA by ship type, September 2012



Source: CNA calculations from the Total Force Manpower Management System (TFMMS) (for average billets per UIC) and the Officer Master File (OMF) (for average SWO O1-O2 inventory assigned per UIC) as of the end of September 2012.

Figure 3. Average O1 and O2 OOE per hull by various ship types



Source: CNA calculations from TFMMS (for average billets per UIC) and the OMF (for average SWO O1-O2 inventory assigned per UIC) as of the beginning of each FY.

Results

SWO retention and economic conditions

We estimate the relationship between retention and the economic indices (level and growth) described in the methodology section (and appendix A) and illustrated in Figure 1. To do so, we must make an assumption about when economic conditions affect retention relative to SWOs' MSR. In our preferred model, we assume that the economic conditions that matter are those in the quarter of an officer's MSR. Table 2 displays the estimated marginal effects of the two economic indices on SWO retention from our preferred model and six other model types. The alternate models are briefly described in the footnotes to table 2.

We find that in our preferred model, the economic *level* index has a substantive and statistically significant relationship with conventional SWO retention. Each 1-point increase in the index (i.e., an increase of one positive standard deviation in the index, indicating a worsening of the economy) corresponds to a 2.6-percentage point increase in conventional SWO retention. We find no relationship between the economic level index and SWO(N) retention or between the economic *growth* index and retention of either type of SWO.

Except where explicitly noted, our preferred and alternate models include a range of other variables to control for their effect on SWO retention, including such demographic variables as gender, marital and dependent status, and race/ethnicity, as well as Navy career variables, such as performance in precommissioning programs, accession source, and the effect of OOE on board the ships to which SWOs are first assigned. Appendixes B and C contain the full set of regression results for the preferred model for conventional SWOs and SWO(N)s, respectively.

Table 2. Economic conditions and retention (marginal effects)

Type of SWO	Economic index	Preferred model[a]	Alternate models					
			(1)[a]	(2)[a]	(3)[a]	(4)[a]	(5)[a]	(6)[a]
Conventional	Level	2.6***	2.6***	7.3	2.1***	1.9**	1.8	2.8***
		(0.6)	(0.6)	(4.2)	(0.6)	(0.6)	(1.6)	(0.8)
	Growth	0.1	0.1	-0.4	-0.3	-0.7	-0.4	0.2
		(0.6)	(0.6)	(1.6)	(0.6)	(0.5)	(1.1)	(0.7)
SWO(N)	Level	1	0.9	1.8	-0.1	1	12.8*	1.1
		(1.7)	(1.6)	(10.8)	(1.8)	(1.7)	(5.1)	(2.2)
	Growth	-0.8	-0.8	-6.3	0.7	-0.9	-7	-0.7
		(1.5)	(1.4)	(4.4)	(1.5)	(1.5)	(3.7)	(1.7)

[a.] Our preferred model is estimated using ordinary least squares (OLS). See Appendixes B and C for the details of the variables included in the full regression of our preferred model for conventional SWOs and SWO(N)s, respectively.

(1) is identical to our preferred model but is estimated using logistic regression.
(2) is estimated using OLS and includes FY indicator variables.
(3) redefines retention from MSR-1 to MSR+2.
(4) uses economic indices calculated at MSR-1 instead of the quarter in which MSR occurs.
(5) is estimated using data from before FY 2006.
(6) is estimated using data from FY 2006 and later.

* Indicates statistical significance at the 0.05 level.

** Indicates statistical significance at the 0.01 level.

*** Indicates statistical significance at the 0.001 level.

Our results for the estimated effect of the economic indices are fairly consistent across different model specifications for conventional SWO retention except for alternate model (2). The results of the different specifications follow:

- One exception to consistency of model results is the estimated effect of the economic index on conventional SWO retention when we account for idiosyncratic yearly retention effects (alternate model (2)). When we account for the fiscal year in which MSR occurred, the effect of the economic index increases but loses statistical significance. This suggests that including a variable indicating fiscal year mitigates the responsiveness of SWO retention to economic conditions. However, because the effects of yearly indicator variables are not known in advance, model (2) is useful only for describing the historical relationship, not for projecting future retention.

- The estimates are moderately sensitive to changes in definitions of retention. For example, alternate model (3) shows that the effects of the economic index measured in the quarter of MSR persist through two years after MSR.

- The estimates are moderately sensitive to our assumption about when the economy affects the retention decision. When we measure the economic level index a year earlier than MSR, the effect of the index is still statistically significant but is smaller than when we measure the index in the quarter of MSR (see alternate model (4)).

- The estimated effect of the economy on conventional SWO retention is smaller when we include only years before 2006. This suggests that a model based solely on pre-2006 data would have underestimated the retention response to the historically poor economic conditions of the late 2000s (see alternate models (5) and (6)).

While we do not find any relationship between the economy and SWO(N) retention (defined here as officers who remain in the SWO(N) community), we do find a relationship between the economic level index and the degree to which officers transfer from the SWO(N) community to the conventional SWO community. While the share of SWO(N)s who make this transfer in our sample is small (around 3 percent of SWO(N)s), the estimated relationship is quite large. Each unit increase in the economic level index (a worsening of the economy) is predicted to increase the transfer rate by 2.7 percentage points, as Table 3 shows. This suggests that transfers from the SWO(N) community to a conventional SWO community are more likely to occur when the civilian economy is weaker.

Table 3. Economic conditions, SWO(N) retention, and transfers from SWO(N) to conventional SWO (marginal effects)[a]

Economic index	Leave the Navy	Remain a SWO(N)	Transfer to conventional SWO
Level	-3.5*	0.8	2.7***
	(1.6)	(1.6)	(0.7)
Growth	1.5	-1.1	-0.4
	(1.4)	(1.4)	(0.4)

[a.] The effect of economic indices on SWO(N)s leaving the Navy is the negative of the sum of the effects on remaining a SWO(N) and on transferring to the conventional SWO community. Although the effect of the economic level index on transferring to the conventional SWO community is positive and statistically significant, very few officers follow this path (less than 3 percent of the SWO(N) sample).

* Indicates statistical significance at the 0.05 level.

** Indicates statistical significance at the 0.01 level.

*** Indicates statistical significance at the 0.001 level.

A key question for policy-makers is whether using the economic level index is worth the cost. Our estimates suggest that models that include economic indices composed of several measures of economic activity fit the data better than do models using the only the unemployment rate. Thus, if retention were modelled using only the

unemployment rate as a proxy for economic conditions, we would expect that our projections of the SWO retention rate would less accurate than projections made using economic indices.

SWO retention and OOE

In this subsection, we present our estimates of the relationship between SWO retention and the amount of OOE on ships to which SWOs were first assigned. As we described earlier, our preferred models and alternate models include a range of other variables to control for their effect on SWO retention except where explicitly noted. Appendixes B and C provide the details on the full regression results of our preferred models for conventional SWO and SWO(N) retention, respectively.[8]

We focus on the level of early-career SWO OOE that exists on an officer's first ship and estimate whether there are different effects on retention based on whether the manning overages occur in ensign billets (denoted O1 OOE) or LTJG (denoted O2 OOE) billets. As Table 4 shows, we find no effect of OOE on the retention of conventional SWOs using either measure of OOE. This estimated non-effect is consistent across a variety of alternate models (see notes to Table 4 on the next page for a brief description of the alternate models).

For SWO(N)s, we estimate that OOE, particularly O2 OOE, has a statistically significant relationship to retention; in fact, we estimate that retention is higher among those whose first assignment was overmanned. This result is fairly robust across models, and there is (weak) evidence that the effect is persistent across time: alternate model (3) shows continuation to two years after MSR. The effect, while smaller, is not statistically different from that in our preferred model.

Table 5 illustrates that the SWO(N) results shown in Table 4 are gender dependent. Specifically, the O2 OOE effect from Table 4 is driven almost exclusively by the women in our sample.

[8] Despite a binary outcome variable, we use OLS instead of a logistic regression model as our preferred model for two reasons: the OLS coefficients are significantly easier to interpret, and the marginal effects are almost identical across the two models (as alternate model (1) shows throughout this paper). This choice is not without controversy, but the use of OLS in the presence of a binary outcome variable is gaining advocates in the civilian literature (see especially [7-8]).

Table 4. Officer overexecution and retention (marginal effects)

Type of SWO	OOE by paygrade	Preferred model[a]	Alternate models					
			(1)[a]	(2)[a]	(3)[a]	(4)[a]	(5)[a]	(6)[a]
Conventional	O1 OOE	0	0	0.1	-0.2	0	0.1	0.3
		(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.4)	(0.3)
	O2 OOE	-0.3	-0.3	-0.1	-0.1	-0.3	0	-0.4
		(0.2)	(0.2)	(0.3)	(0.3)	(0.2)	(0.4)	(0.4)
SWO(N)s	O1 OOE	-0.6	-0.5	-0.4	-0.2	-0.5	-1.2	0.4
		(0.6)	(0.6)	(0.7)	(0.6)	(0.6)	(1.1)	(0.9)
	O2 OOE	1.6**	1.7**	2.5***	1.2	1.7**	2.8**	1.6
		(0.6)	(0.6)	(0.7)	(0.7)	(0.6)	(0.9)	(0.9)

[a] Our preferred model is estimated using ordinary least squares (OLS). See appendixes B and C for the details of the variables included in the full regression of our preferred model for conventional SWOs and SWO(N)s, respectively.

(1) is identical to our preferred model but is estimated using logistic regression.
(2) is estimated using OLS and includes FY indicator variables.
(3) redefines the retention from MSR-1 to MSR+2.
(4) uses economic indices calculated at MSR-1 instead of the quarter in which MSR occurs.
(5) is estimated using data from before FY 2006.
(6) is estimated using data from FY 2006 and later.

* Indicates statistical significance at the 0.05 level.

** Indicates statistical significance at the 0.01 level.

*** Indicates statistical significance at the 0.001 level.

Table 5. OOE and the retention of SWO(N)s

OOE by paygrade	Men	Women
O1 OOE	-1	0.6
	(0.7)	(1)
	0	0
O2 OOE	0.6	4.1***
	(0.7)	(1.2)

To summarize, Table 4 and Table 5 suggest that there is no statistically significant relationship between OOE and the retention of conventional SWOs and male SWO(N)s. There is, however, a large relationship between O2 OOE and the retention of female SWO(N)s. We estimate that retention near MSR has been 4.1 percentage points higher for these women for each additional O-2 SWO above billets authorized in their initial assignment.

As we show in Appendix D, the O2 OOE results for female SWO(N)s are fairly consistent across the type of ship to which these officers are initially assigned. We also find that O1 OOE, while usually unrelated to retention (as shown above), appears to have an impact on the retention of female SWO(N)s who initially serve on frigates. We estimate an 18-percentage-point increase in retention for each additional O1 SWO on board in excess of BA. This result exists for these women only. While this is a relatively small group of women (only 29 in our sample), the result is very stable across a range of alternate models. Moreover, to the extent that we can detect, it is not an artifact of outliers. We cannot explain this result and do not attempt to do so here. If this result is of interest to policy-makers or other stakeholders, we suggest that additional research be conducted on the subject.

Conclusions and Policy Implications

In this information memorandum, we estimated the relationship between SWO retention and two characteristics of particular interest: the state of the civilian economy and the amount of OOE on board the ships to which SWOs were first assigned.

For the first characteristic, we identified an index that summarizes the state of the civilian economy. The index is made up of various macroeconomic indicators for which we have a BCEI forecast. We found that conventional SWO retention, defined as remaining in the SWO community from MSR–1 to MSR+1, is correlated with the economic index, holding constant other factors that affect retention. We compared our economic index with the traditional method of summarizing civilian-sector economic activity (i.e., by the civilian unemployment rate) and found that our index was a better fit for observed retention behavior. We estimated that a one-unit increase in the economic index (indicating a worsening of the economy) increased conventional SWO retention by 2.6 percentage points. In contrast, the estimated relationship between the economic index and SWO(N) retention was generally small and inconsistent across models.

For future work, our results provide the means to convert forecasts of economic measures into a forecast of the economic index. The forecasted index value can be used to forecast changes in conventional SWO retention due to economic conditions over the next several years.

Regarding the second characteristic, we measure OOE on the platform to which SWOs are first assigned at the beginning of the quarter that SWOs arrive. We found that early-career OOE has no impact on retention near MSR for conventional SWOs (male or female) or for male SWO(N)s. We found that the only group for which we estimate a statistically significant effect of OOE on retention is the SNO(N) contingent. For these women, the estimated relationship is quite large; two-year retention rates around MSR increase by 4 percentage points for each additional SWO in paygrade O2 above the number of authorized billets.

We also found that OOE in SWO O1 billets has a very strong positive effect on the retention of female SWO(N)s whose careers began on frigates; this result was limited to these officers only. We cannot explain this relationship, and it affected a relatively small number of women. However, the estimated retention response is quite robust and may be worth investigating further. More generally, discussions with SWO

community stakeholders may reveal why the positive association exists between SWO O2 OOE and female SWO(N) retention, and between O1 OOE and female SWO(N) retention for those who were first assigned to frigates.

We make the following two recommendations:

- Incorporate the effect of a forecast of the civilian economy in estimates of future SWO retention.
- Undertake additional analysis to understand if the estimated positive correlation of OOE and female SWO(N) retention can be leveraged to distribute these officers to their first sea assignments in ways that could increase their retention.

Appendix A: The Economic Indices

In this appendix, we briefly describe the construction and interpretation of our economic indices. In general, the discussion here will be similar to the discussion in references [3, 6] except where noted.

First, We use principal component analysis (PCA) to distill the information from various economic measures into an index. Specifically, PCA identifies the common variation in the normalized values of our economic measures to produce a single index. In a simple example, if 5 variables in a set of 10 variables tend to move together, PCA will identify this common variation and use it to create an index. For more information on the estimation process, see [9].

In this study (as in [3, 6]), we limited the range of possible economic measures to those available with BCEI forecasts. This ensures that the resulting indices will also be forecastable. This comes with a cost, however; many economic measures that might offer a broader look at the civilian job market (e.g., labor force participation) and would thus add valuable information to our indices do not come with BCEI forecasts. As such, we are likely giving up some measure of precision in our estimated relationship between our economic indices and SWO retention in exchange for the ability to forecast the indices and project SWO retention.

In the BCEI, there are monthly updates to forecasts of quarterly values of 12 economic measures:

1. The growth rate of real GDP
2. The growth rate of the GDP price index
3. The growth rate of the consumer price index
4. The growth rate of the producer price index
5. The growth rate of industrial production
6. The growth rate of disposable personal income
7. The growth rate of personal consumption expenditures
8. The unemployment rate
9. The interest rate on 3-month Treasury bills

10. The interest rate on 10-year Treasury notes
11. The dollar value of the change in business inventories
12. The dollar amount of net exports

In [3, 6], we found that economic measure 12 was generally unrelated to the rest, so we omitted this measure from the analysis. We do so here as well. Then, we identified three indices: a level index, a growth index, and an inflation index. The inflation index had no relationship with enlisted retention as shown in [3]. As such, for this analysis, we do not construct an inflation index or use the economic measures needed for it (economic measures 2-4). This is a key difference in the indices constructed for the enlisted analysis in [6] and those constructed for the current officer analysis, although Figure 3 shows that the differences in the economic level indices for the enlisted analysis and the current officer analysis are quite small.

Finally, the two indices used in this paper were based, to lesser and greater extents, on the normalized values of each of the remaining eight candidate economic measures. Converting economic measures into index values is relatively straightforward. First, each economic measure must be normalized; to do so, we subtract the average quarterly value of that measure from its current value, and divide by the standard deviation (SD). We then have normalized values for each of the eight measures for each quarter. We apply PCA to the quarterly normalized economic measures to produce index coefficients. The normalized economic measures are then multiplied by the index coefficients. The sum of the coefficients times the normalized economic measures equals the index value for that quarter. The means, SDs, and index coefficients are shown in Table 6.

To illustrate the process, we give an example using economic measures from the fourth quarter of calendar year 2014 (see table 7).

Recall that the resulting indices have no intuitive scale: the traditional scaling method is to define the index as variable with a mean of 0 and an SD of 1. In other words, each 1-point movement in the normalized index away from the average is equal to one SD. Using the characteristics of the standard normal distribution, we know that the measure of an economy corresponding to an index value of 1 or more is expected to occur about 16 percent of the time (1-in-6 quarters). A value of 2 or more is expected to occur about 2 percent of the time (1-in-50 quarters). A value of 3 or more is expected to be exceedingly rare, occurring about 0.1 percent of the time.[9] Figure 4 shows the values of the economic indices since 1990.

[9] These are symmetric: the same probabilities hold for -1 or less, -2 or less, and -3 or less, respectively.

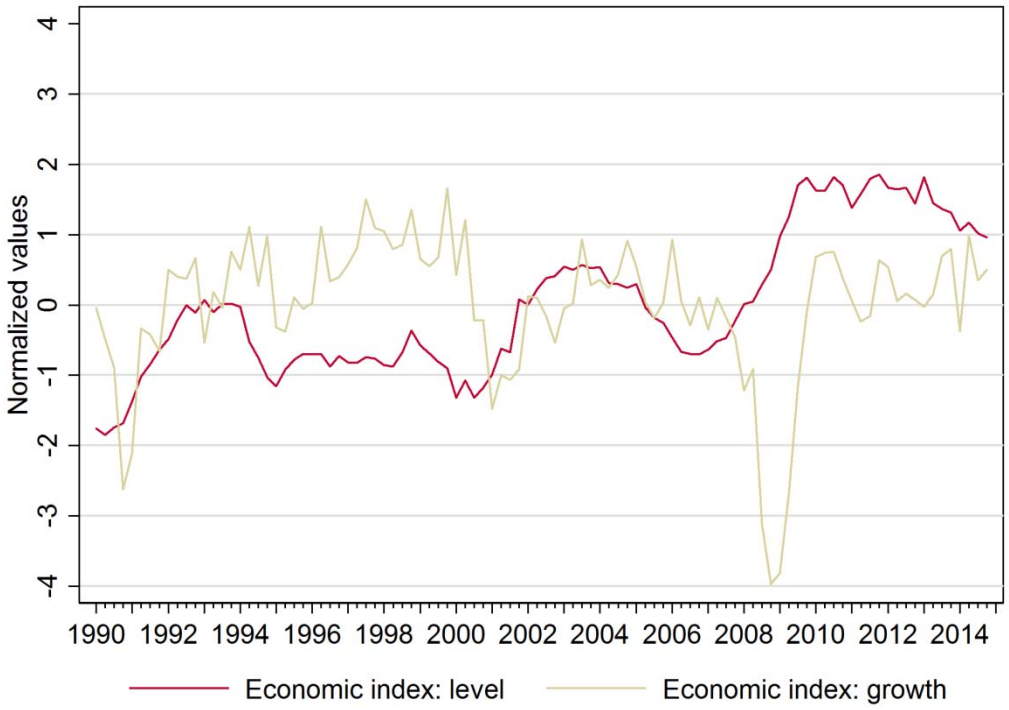
Table 6. Economic index construction

Variable	Mean	SD	Economic level coefficient	Economic growth coefficient
Growth in real GDP	2.44	2.56	0.05	0.31
Growth in industrial production	2.29	4.94	0.09	0.32
Growth in disposable income	2.51	3.76	-0.07	0.14
Growth in personal consumption expenditures	2.69	2.16	0.00	0.27
Unemployment rate	6.13	1.58	0.33	0.02
3-month Treasury bill	3.04	2.26	-0.42	-0.07
10-year Treasury note	4.97	1.77	-0.38	-0.07
Change in business inventories	28.91	52.47	0.01	0.26

Table 7. Generating the index values: an example

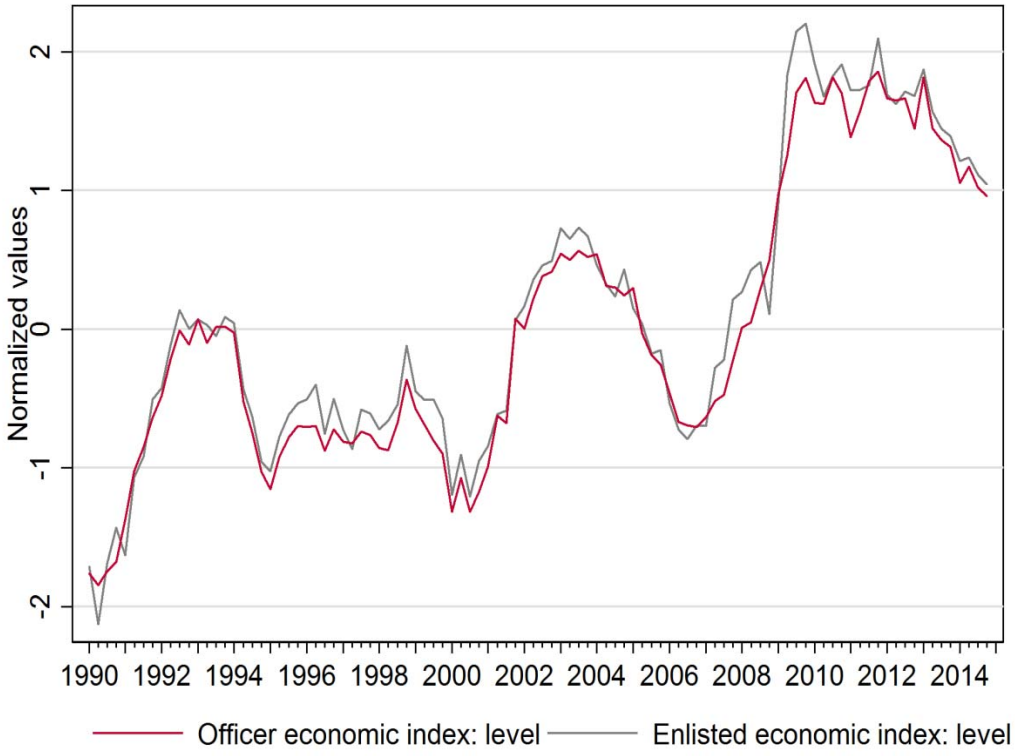
Variable	Value	Minus mean	Divided by SD (normal-ized)	Normalized economic measure times economic index level coefficient	Normalized economic measure times economic index growth coefficient
Growth in real GDP	3.10	0.66	0.26	0.01	0.08
Growth in industrial production	3.70	1.41	0.28	0.03	0.09
Growth in disposable income	2.80	0.29	0.08	-0.01	0.01
Growth in personal consumption expenditures	2.80	0.11	0.05	0.00	0.01
Unemployment rate	6.20	0.07	0.04	0.01	0.00
3-month Treasury bill	0.10	-2.94	-1.30	0.54	0.09
10-year Treasury note	3.30	-1.67	-0.95	0.36	0.07
Change in business inventories	57.70	28.79	0.55	0.01	0.14
			Index values	**0.96**	**0.50**

Figure 4. Forecastable economic indices created for SWO retention analysis



Finally, we compare the economic level index in this paper with that estimated in CNA's enlisted study [3, 6]. As Figure 5 shows, the indices are very similar (as expected, since the compositions of the indices are very similar).

Figure 5. Comparison of forecastable officer and enlisted economic level indices



Appendix B: Conventional SWOs

In this appendix, we document the full estimation results for conventional SWOs from our preferred model of retention. We also report the sample mean and standard deviation of each variable in the preferred model. These are shown in Table 8. Stand-alone independent variables (e.g., the economic indices) have coefficients and standard errors that match those in Table 2. Variables that are combined (or "crossed") with other variables (e.g., O2 OOE) require the appropriate combination of all applicable coefficients (and, occasionally, variable means) to calculate the correct marginal effects.

One result of note is that men who are pursuing a graduate degree in their first year of commissioned service have notably lower retention than those who do not pursue a graduate degree in YCS 1. Their retention is more than 14 percentage points lower. This effect is persistent; when we look at continuation to MSR+1 (not shown here), the effect remains. Furthermore, as we show in the next appendix, the opposite holds for SWO(N)s: they are much more likely to retain sailors who pursued a graduate degree in YCS 1 (although the effect is less persistent). If the Navy desires to keep these officers, it may be worth investigating why there are differences in the retention effects of YCS 1 education in the conventional SWO and SWO(N) communities.

Table 8. Full regression results and summary statistics for conventional SWOs

Variable	Coefficient	Standard error	Mean	SD
Economic index: growth	0.08	(0.57)	-0.04	0.96
Economic index: level	2.61	(0.59)	0.28	1.01
O1 OOE	-0.14	(0.32)	2.97	3.28
First platform: cruisers	0.61	(2.71)	0.18	0.39
First platform: destroyers	1.29	(2.40)	0.33	0.47
First platform: frigates	1.83	(2.86)	0.18	0.39
First platform: other	-0.14	(3.21)	0.05	0.23
First platform: cruisers * O1 OOE	0.30	(0.59)	0.37	1.33
First platform: destroyers * O1 OOE	0.21	(0.44)	0.70	1.85
First platform: frigates * O1 OOE	0.12	(0.52)	0.62	1.78
First platform: other * O1 OOE	-1.18	(0.96)	0.04	0.63

Variable	Coefficient	Standard error	Mean	SD
Female	-11.34	(2.55)	0.20	0.40
Female * O1 OOE	0.12	(0.42)	0.70	2.06
O2 OOE	-0.36	(0.47)	1.49	2.33
First platform: cruisers * O2 OOE	-0.54	(0.72)	0.22	1.11
First platform: destroyers * O2 OOE	0.35	(0.60)	0.50	1.51
First platform: frigates * O2 OOE	0.18	(0.78)	0.26	0.99
First platform: other * O2 OOE	-0.03	(1.10)	0.04	0.58
Female * O2 OOE	0.18	(0.59)	0.34	1.26
Age	-4.84	(4.75)	27.03	2.51
Age^2	0.10	(0.08)	736.82	143.62
In YCS 3: any time at sea	41.74	(3.32)	0.98	0.13
At YCS 3: married	3.00	(1.33)	0.33	0.47
At YCS 3: divorced	-0.09	(3.61)	0.06	0.24
At YCS 3: married * female	-4.36	(3.95)	0.03	0.16
At YCS 3: divorced * female	-9.94	(4.87)	0.04	0.19
Hispanic	2.97	(2.00)	0.08	0.28
Race: API	4.90	(2.59)	0.04	0.21
Race: Black	2.87	(1.68)	0.11	0.32
Race: Native American	-4.21	(6.65)	0.01	0.08
Race: Other	2.13	(2.58)	0.05	0.21
Race: Unknown	3.61	(3.69)	0.02	0.14
Student at MSR-1	4.02	(1.77)	0.11	0.31
Student at MSR-1 * female	10.39	(4.98)	0.02	0.12
Accession source: NROTC	-1.66	(1.88)	0.34	0.47
Accession source: Naval Academy	0.06	(1.73)	0.38	0.48
Accession source: enlisted to officer	9.72	(2.09)	0.11	0.31
Graduate education in YCS1	-14.61	(5.16)	0.02	0.13
Graduate education in YCS1 * female	11.25	(9.32)	0.01	0.07
Started as a SWO(N)	-25.46	(3.94)	0.02	0.13
Constant	83.58	(68.14)		

Appendix C: SWO(N)s

In this appendix, we document the full estimation results for conventional SWOs from our preferred model of retention as well as the sample mean and standard deviation of each variable in the preferred model. Stand-alone independent variables (e.g., the economic indices) have coefficients and standard errors that match those in Table 3. Variables that are combined (or crossed) with other variables (e.g., O2 OOE) require the appropriate combination of all applicable coefficients (and, occasionally, variable means) to calculate the correct marginal effects.

Table 9. Full regression results and summary statistics for SWO(N)s

Variable	Coefficient	Standard error	Mean	SD
Economic index: growth	-0.79	(1.47)	-0.12	1.06
Economic index: level	1.02	(1.70)	0.32	0.95
O1 OOE	-2.01	(1.43)	2.67	3.22
First platform: cruisers	-1.81	(11.19)	0.27	0.44
First platform: destroyers	-3.31	(10.85)	0.40	0.49
First platform: frigates	-16.22	(13.06)	0.13	0.33
First platform: other	10.95	(11.81)	0.07	0.25
First platform: cruisers * O1 OOE	1.11	(1.82)	0.47	1.61
First platform: destroyers * O1 OOE	0.80	(1.63)	0.84	1.87
First platform: frigates * O1 OOE	2.52	(1.96)	0.49	1.65
First platform: other * O1 OOE	0.21	(2.09)	0.00	0.90
Female	-14.59	(5.84)	0.28	0.45
Female * O1 OOE	1.70	(1.09)	0.88	2.13
O2 OOE	-0.89	(2.10)	1.47	2.55
First platform: cruisers * O2 OOE	2.63	(2.32)	0.40	1.58
First platform: destroyers * O2 OOE	1.06	(2.24)	0.65	1.72
First platform: frigates * O2 OOE	4.11	(3.02)	0.20	0.82
First platform: other * O2 OOE	-2.15	(2.38)	0.00	1.02
Female * O2 OOE	3.57	(1.32)	0.38	1.37
Age	-23.22	(13.71)	26.85	2.02

Variable	Coefficient	Standard error	Mean	SD
Age^2	0.46	(0.23)	725.05	116.47
In YCS 4: any time at sea	-3.04	(7.86)	0.94	0.24
At YCS 4: married	9.50	(3.53)	0.37	0.48
At YCS 4: divorced	10.21	(10.21)	0.06	0.24
At YCS 4: married * female	-10.21	(8.12)	0.04	0.21
At YCS 4: divorced * female	-13.13	(12.99)	0.04	0.19
Hispanic	6.66	(7.20)	0.05	0.22
Race: API	-1.61	(7.27)	0.04	0.21
Race: Black	3.43	(6.48)	0.05	0.22
Race: Native American	27.21	(23.20)	0.00	0.06
Race: Other	6.82	(7.74)	0.04	0.18
Race: Unknown	-2.31	(10.41)	0.02	0.14
Student at MSR-1	7.04	(8.49)	0.06	0.24
Student at MSR-1 * female	-2.10	(15.71)	0.02	0.14
Accession source: NROTC	6.49	(4.42)	0.32	0.47
Accession source: Naval Academy	9.24	(4.48)	0.37	0.48
Accession source: enlisted to officer	13.75	(6.10)	0.08	0.27
Graduate education in YCS1	23.98	(8.81)	0.05	0.22
Graduate education in YCS1 * female	9.26	(15.91)	0.02	0.13
Constant	342.70	(199.67)		

Appendix D: OOE and Female SWO(N)s

In the main body of this paper, we noted that the relationship between female SWO(N) retention and O2 OOE was reasonably consistent across ship type; however, we estimate a statistically significant correlation of O1 OOE and retention only for female SWO(N)s whose first assignment was on a frigate. We show both here, with a particular emphasis on the stability of the O1 OOE effect.

In Table 10, we show the results of allowing the effect of early-career OOE to differ by ship type (a modification to the preferred model in the main text). We find that the large effect is driven by three of the five ship types, which represent the majority of women in our sample. As such, the result is largely generalizable to female SWO(N)s.

Table 10. Estimated marginal effects of OOE on the retention of female SWO(N)s

	Amphibious ships	Cruisers	Destroyers	Frigates	Other
O1 OOE	-1.7	0.5	-1.5	18***	1.5
	(1.9)	(2.4)	(1.9)	(3.3)	(3.3)
O2 OOE	6.4*	0.7	4.7**	7.7*	-1.1
	(3.0)	(2.5)	(1.7)	(3.4)	(3.8)
Number	57	87	127	29	15
Retention percentage	47.4	49.4	48.8	51.7	53.3

Table 10 also shows the O1 OOE results for female SWO(N)s on frigates. Given the average MSR–1 to MSR+1 retention rate of 51.7 percent, an increase of 18 percentage points per additional O1 in excess of BA is very large. Furthermore, we find no evidence of the effect among other women.

One possible explanation is that the O1 OOE result is the result of an odd interaction with our variable that estimates the effect of these women starting their careers on frigates; the coefficient (not marginal effect) of this variable decreases when we

modify the regression to allow for different OOE effects by gender and ship type together (instead of separately). To examine this possible explanation in more detail, we estimate a retention model using only data on women who started their careers as SWO(N)s on frigates. (Note that our sample size is very small — only 29 observations, as indicated in the frigates column in Table 10.) We compare these estimates to those obtained by estimating identical models using only data on women who started their careers as SWO(N)s on each of the other types of ships. Furthermore, we model retention as a function of O1 and O2 OOE only. This eliminates any distortions introduced with other variables. This simple model can then be written as

$$retention_i = constant + \beta_1 * OOE\ 1 + \beta_2 * OOE\ 2 + error_i.$$

Table 11 shows the results of these five regressions, where the number represents not only the group size, but also the sample size for each of the regressions. The results are consistent with those found in Table 10. In fact, given the much smaller sample size of the regression for female SWO(N)s on frigates, the consistency of the estimates is somewhat surprising.

Table 11. Marginal effects of OOE on female SWO(N) retention in a simplified model estimated separately for each ship type

	Amphibious ships	Cruisers	Destroyers	Frigates	Other
O1 OOE	-1.2	1.0	-0.3	18.2***	2.1
	(2.0)	(3.3)	(1.8)	(4.0)	(3.8)
O2 OOE	6.7*	1.9	5.7**	5.9	-0.6
	(3.3)	(2.7)	(1.9)	(4.2)	(4.0)
Number	57	87	127	29	15
Retention percentage	47.4	49.4	48.8	51.7	53.3

Another possibility is that this result is simply an artifact of randomness in the data. We expect that we will estimate statistically significant effects (at the 0.05 confidence level) when no true effect exists around 5 percent of the time. That is, given 20 random regressions using pairs of variables that have no true relationship, we would expect to estimate that one pair of variables has a "statistically significant effect." Here, this seems unlikely. The estimated O1 OOE effect is statistically significant not only at the 0.05 level, but also at a level that is less than 0.1 percent. That is, our false positive rate is not 1-in-20 but less than 1-in-1,000.

Thus, we have evidence that the relationship between OOE and female SWO(N) retention exists, that it is not an artifact of other variables in the regression (ruled out by results displayed in Table 11), and that it is unlikely to be a false positive (ruled out by the high level of precision of the estimates). The two most likely remaining options are that it is an actual effect that we cannot explain or that it is an artifact of the data. We performed a variety of other tests on the models and examined the records in detail to determine if any other explanations for the result could be found. We were unable to find an explanation.

To summarize, the O1 OOE-female SWO(N) retention result is not readily explained, is very robust, and does not appear to be driven by some oddity in the model or in the data. As such, we suggest that those who find this result important engage stakeholders to identify reasons why O1 OOE appears to have affected the retention of female SWO(N)s who were first assigned to frigates to such a large extent. These discussions may reveal a heretofore unseen distortion of the data or they may reveal a valid reason why the estimates exist.

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